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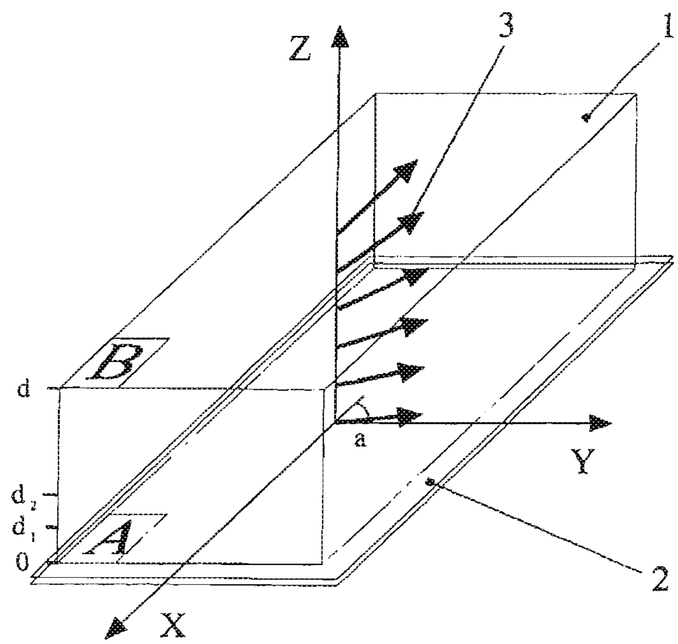
(54) **Title:** OPTICALLY ANISOTROPIC FILM AND METHODS OF ITS OBTAINING



(57) **Abstract:** The invention can be used for fabrication of devices of various purpose, including devices of representing information with liquid crystals, in illuminating devices, decorative products, for fabrication of trade marks and service signs, etc. The essence of the invention optically anisotropic film of molecularly oriented organic matter has varying direction of optical axis (axes) throughout its thickness on at least a part of its thickness, for at least one region of the spectrum, on at least a part of the film's area. A method of fabrication of the given film is proposed.

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OPTICALLY ANISOTROPIC FILM AND METHODS OF ITS OBTAINING

BACKGROUND

Field

The invention could be used for manufacturing devices of various purposes including information liquid crystal displays, illuminating equipment, decorative products, for manufacturing trademarks and service signs, etc.

Description of the related art

There is a known optically anisotropic film, which is used as a polarizer with varying direction of the optical axis of the film's material throughout the thickness of the polarizing film (RU 2110818, G02B, 05/10/98). In the known polarizer the polarizing layer (film) consists of separate elements, optical axes of which directed at a certain angle relative to each other, varying in the range from 0 to 90°.

There is also a known method of obtaining optically anisotropic film, which is the polarizer, involving application of an organic dye solution in the state of lyotropic liquid crystal (LLC), with subsequent removal of the solvent (RU 2110818). In the process of application, an orienting influence is imposed, which is directed along the surface of the substrate at different angles to one of its sides (the angle varies from 0 to 70°).

In the known polarizer the variation of the polarizing axis through thickness is not taken into account, which narrows the area of its application. To achieve an approximate direction of the optical axis throughout the thickness of the polarizer with traditional methods is possible only by sequential application of several anisotropically absorbing layers with various directions of optical axes. Such process is technologically difficult and, besides that, during application of every new layer, the previous layer may develop defects in the ordered molecular structure, which leads to lowering of the polarizing effectiveness and uniformity of properties over the entire area of the polarizer. As a result of this, an intermediary protective film should separate the layers in order to obtain the necessary degree of orientation, which hinders the process of manufacturing, increases the thickness of the polarizer and worsens optical properties of the polarizer even further.

Summary

Technical result of the disclosed invention is the broadening of the functional possibilities of application of the optically anisotropic films while simplifying the method of manufacturing, as well as providing reproducible optical parameters over the entire area and volume of the film and achieving high levels of optical anisotropy.

The technical result is achieved by the fact that the optically anisotropic film of the molecularly ordered organic matter, has varying direction of the optical axis (axes) throughout the thickness of the film, in at least a part of the film's thickness, for at least one region of the spectrum and on at least a part of the area of the film.

The technical result is also achieved by the fact that the film is anisotropically absorbing and/or phase-shifting for at least one region of the spectrum.

The technical result is also achieved by the fact that the first derivative of the function, describing the variation of the optical axis angle throughout the thickness of the film is continuous (smooth). Besides that, the function describing the angle of twist of the optical axis throughout the thickness of the film is not symmetrical around any section plane parallel to its surface.

The technical result is also achieved by the fact that the film is obtained from a liquid crystal of at least one organic matter, which forms lyotropic or thermotropic liquid-crystal phase, via application of the liquid crystal onto the substrate with the use of the external orienting influence and drying, while at least a part of the substrate surface possesses surface anisotropy, and the direction of the external alignment influence does not coincide with the direction induced by at least a part of the substrate surface.

The technical result is achieved also by the fact that the variation of the optical axis direction throughout the thickness of the film is provided in the process of its manufacturing via the impact on the LC by the anisotropic surface of the substrate and the external alignment influence, while the directions of the mentioned orienting actions do not coincide.

The technical result is also achieved by that fact that the law of variation of the polarizing axis direction through out the thickness of the film is determined by the anisotropy of the substrate surface and/or the direction and force of the external

alignment influence and/or the thickness of the forming film and/or the viscosity of the employed liquid crystal and/or the conditions of its application and drying.

The technical result is also achieved by using, in the capacity of the organic matter, which is used for obtaining the liquid crystal, at least one organic dye featuring in its structural formula at least one ionogenic group, which provides its solubility in polar solvents in order to form lyotropic liquid crystal phase, and/or at least one non-ionogenic group, which provides its solubility in polar or non-polar solvents in order to form lyotropic liquid crystal phase, and/or at least one anti-ion, which in the process of formation of the optically anisotropic film either remain in the structure of molecules or not.

The technical result is also achieved by using, in the capacity of the organic dye, at least one organic dye of the form:

$$\{K\}(M)_n,$$

where, K – is the dye, chemical formula of which contains ionogenic group or several groups (same or different), which provide its solubility in polar solvents in order to form lyotropic liquid-crystal phase, M – anti-ion, and n- the number of anti-ions in a molecule of the dye, which could be a fraction in the case of sharing of one anti-ion by several molecules and in the case of n>1 anti-ions could be different.

The technical result is also achieved by the fact that the film is formed by numerous supra-molecular complexes of one or several organic matters, and the supra-molecular complexes are oriented in a particular direction in order to polarize light.

The technical result is also achieved by that fact that the film consists of at least two fragments, situated in one plane, axes of polarization of which on the surface of the film (near-surface layer) are directed at an angle relative to each other ranging from 0 to 90°.

The technical result is also achieved by the fact that on the surface of the film there has been formed or applied at least one optically anisotropic film, and/or at least one phase-shifting film, and/or at least one birefringent film, and/or at least one alignment film, and/or at least one protective film, and/or at least one film simultaneously performing functions of any combination of at least two of the mentioned films.

The technical result is also achieved by the fact that the film is the polarizing film, and/or the phase-shifting film, and/or alignment layer, and/or protective film, and/or a film simultaneously functioning as any combination of at least two of the mentioned films on at least a part of the polarizers thickness and/or in at least one region of the spectrum and/or on at least one part of the polarizers area.

The technical result is also achieved by that fact that the substrate is made out of a polymer material or glass, and has flat, or concave, or convex, or varying according to a certain law shape of the surface, and anisotropic properties of the substrate's surface on at least a part of its surface provided by either chemical bonds or by a relief or texture formed on substrate's surface either out of the material of the substrate itself or out of an applied onto the substrate's surface material.

The technical result is also achieved by the fact that optically anisotropic film is obtained by a method involving application of liquid crystal of at least one organic matter, with removal of the solvent in the process, and/or after formation of the film an alignment influence is imposed onto the liquid crystal and the film is formed on the anisotropic surface of the substrate or alignment layer, while the direction of the alignment influence and the direction of surface orientation of the substrate or the layer situated at an angle ranging from 0 to 90°.

In the disclosed method, the substrate surface and/or alignment layer can consist of at least two regions with different direction of the surface orientation.

In the disclosed method for obtaining surface anisotropy on the surface of the substrate one could form a regular structure or a relief either from the material of the substrate, or from the applied onto the substrate material via mechanical and/or chemical and/or other treatment.

In the disclosed method in order to provide additional variation of polarizing axis direction throughout the thickness of the film in the process of film formation, the direction of the alignment influence over the surface can be varied.

In the disclosed method, one can form regions with various properties, including different direction of the surface orientation, on the surface of the substrate.

Particular organic matters, on the basis of which one can obtain films with optical anisotropy are known. Those include, for example, the following dyestuffs:

- polymethine dyestuffs, for example, "psuedoisocyanine", "pinacyanol"
- triarylmethane dyestuffs, for example:
"osnovnoi biriuzovii" (C.I. Basic Dye, 42035 (Turquoise Blue BB (By)))
"kislotnii yarko-goluboi 3" (C.I. Acid Blue 1, 4204)
- diaminoxanthene dyes, for example,
"sulforhodamine S" (C.I. Acid Red 52, 45100 (Sulforhodamine B))
- acridine dyes, for example:
"osnovnoi zholtii" (C.I. Basic Dye, 46025 (Acridine Yellow G and T(L)))
- sulfonation products of acridine dyes, for example:
of "trans-quinacridone" (C.I. Pigment Violet 19, 46500 (trans-Quinacridone)):
- water-soluble derivatives of anthraquinone dyes, for example:
"aktivnii yarko-goluboi KH" (C.I. Reactiv Blue 4, 61205):
- sulfonation products of vat dyes, for example:
of "flavantrone" (C.I. Vat Yellow 1, 70600 (Flavanthrone))
of "indantrenovii zholtii" (C.I. Vat Yellow 28, 69000)
of "kubovii zholtii 4K" (C.I. Vat Orange 11, 70805)
of "kubovii tyomno-zelenii Zh" (C.I. Vat Green 3, 69500)
of "kubovii fioletovii S" (C.I. Vat Violet 13, 68700)
of indanthrone (C.I. Vat Blue 4, 69800 (Indanthrone))
of perylene violet dye (CAS: 55034-81-6)
of "kubovii alyi 2Z" (C.I. Vat Red 14, 71110)
- azo-dyes, for example:
Benzopurpurine 4B (C.I. Direct Red 2, 23500)
"Pryamoy zheltii svetoprochniy O"
"Pryamoy zheltii svetoprochniy" (C.I. Direct Yellow 28, 19555)
- water soluble diazine dyes, for example:
C.I. Acid Blue 102, 50320
- sulfonation products of dioxazine dyes, for example:
of "*pigment fioletovii dioxazinovii*" (C.I. Pigment Violet 23, 51319).
- water-soluble thiazine dyes, for example:
C.I. Basic Blue 9, 52015 (Methylene Blue)
- water-soluble derivatives of phtalocyanine dyes, for example:
cupric octacarboxyphtalocyanine salts
- fluorescent bleaches,

And also other colorless organic substances, for example di-sodiumchromoglycate.

Optically anisotropic film is a film of material possessing anisotropy of optical properties, which in a general case are characterized by the complex refraction coefficient $N_j=n_j-i*k_j$, where n_j and k_j are the main components of tensors of the refraction coefficient and absorption coefficient accordingly. The value of the refraction coefficient for the majority of the organic materials varies in the range from 0 to 1.5. Anisotropy of n_j determines the phase-shifting properties of the film, while anisotropy of k_j determines polarizing properties. Therefore, optically anisotropic film in a general case is simultaneously a phase-shifting and polarizing one. In a particular case, when the absorption coefficient is close to 0 in the visible light spectrum, the film in this spectrum range is only phase-shifting, and it may absorb light (be a polarizer) in the UV range of the spectrum.

Depending on the molecular structure the absorption bands can be in different spectral ranges: UV, visible and IR, or in several spectral ranges. Therefore, a film in one range of spectrum can feature polarizing and phase-shifting properties and only phase-shifting in the other.

By creating the variation of the optical axis direction throughout the thickness, one could change not only the direction of the polarizing axis for a polarizing film, but also the direction of the "fast" and/or "slow" axis for a phase-shifting film. This has an influence not only on the intensity of the passing linearly polarized light depending on the orientation of its polarizing plane, but also on the degree of ellipticity (strongly elliptical vs. weakly elliptical) of its polarization and the direction of the axes of this ellipse at the exit from the film. For example, in the case when absorption is small and the following conditions hold: $(n_o-n_e)d > \lambda/4$, where n_o and n_e – are the refraction coefficients of the ordinary and extraordinary rays, accordingly, and d – is the thickness of film, a screw-like structure will rotate the polarization plane to a predetermined angle if its polarization plane upon incidence on the lamina is parallel or perpendicular to the direction of the fast axis on that plane. The value of birefringence $*n = n_o - n_e$, for the materials used for obtaining of the herein declared device (organic dyes, forming lyotropic liquid crystal phase), ranges from 0.1 to 0.9. Therefore the mentioned earlier condition is attained at the

film thickness from 0.15 to 1.3 μm, which lays within the limits of usually obtained thickness. Variation of polarization plane orientation or the presence of absorption of ordinary or extraordinary ray will affect ellipticity of the exiting from the film light. All these effects, in the end, affect the optical properties of the herein declared device and depend on the degree of optical anisotropy of the film, the direction of propagation of polarized light, the thickness of the film and the law of the orientation variation.

Drawings

The present disclosure is illustrated by the enclosed drawings of which:

Figure 1 schematically shows the composition of the optically anisotropic film with screw-like structure.

Figure 2 represents the dependence of optical axis orientation variation (the angle of twist) throughout the thickness of the film.

Detailed description

In the figure 1, the optically anisotropic film 1, is represented in the system of coordinates XYZ, where the X-axis coincides with the direction of the external alignment influence, imposed during film formation; Z-axis is situated along the normal to the film's surface. In the layer of the film 1, adjacent to the substrate 2, the optical axis 3 of the film 1 is directed at a certain angle φ to the X-axis and this direction is conserved until a certain thickness d_1. This direction is introduced by the oriented surface processing of the substrate 2 or previously applied additional organic layer. The oriented processing is implemented via rubbing, photo-orientation or other method. Then, the optical axis is rotated, in the span $d_1 - d_2$, to the direction coinciding with the X-axis (direction of the external alignment influence), and retains this orientation in the rest of the thickness up to the other surface of the film - d. The rotation of the axis is realized by utilizing the viscous forces during film application with any of the known methods. During that, the optical axis retains its orientation parallel to the substrate surface. Thickness d_1 of the near-surface and the intermediary layer d_2-d_1 depends on rheological properties of the material during its application onto the substrate, material of the surface layer of the substrate, the method of application and other technological factors. The thickness of layer 0-d_1 can have a value from a few percent to tens of percent of the total film thickness.

If the dependence of variation of optical axis orientation is not symmetrical relative to the center of the film's thickness, then optical properties of such lamina also are not symmetrical relative the direction of light propagation. Light transmission coefficient will depend on that from which side the polarized light hits the lamina: from the side of the substrate or from the side of the film.

Lets consider a case where layers $0\text{-}d_1$ and $d_1\text{-}d_2$ are thin compared to the total thickness of the film ($d_1 d_2$ • d) (fig. 2). In the case when linearly polarized light is incident on the film 1 from the side *B* so that its polarization plane is perpendicular to the optical axis of the layer d_1-d, it will be absorbed in that layer and with sufficient thickness the intensity of light could be 1-2% of the initial. Further travel through the layers $0\text{-}d_1$ and $d_1\text{-}d_2$ will have little influence on the intensity of the traveling beam because of their small thickness and the intensity of absorption per unit length in the layer $0\text{-}d_1$ and $d_1\text{-}d_2$ will be smaller than in the layer d_1-d because of rotation of the optical axis. The passing of light through layers $0\text{-}d_1$ and $d_1\text{-}d_2$ makes it elliptically polarized. However, due to the absence of an additional polarizer between the viewer and the lamina, the effect of linear de-polarization remains undetected. Therefore, at the exit from the lamina, we will have the intensity of 1-2% of the initial, which is determined mainly by the thickness of the film d. Upon incidence of flatly polarized light with the same orientation but from the side *A*, part of the film $0\text{-}d_1$ will work as birefringent phase-shifting lamina and at its exit the light will have elliptical polarization, which is further analyzed by the polarizer which in this case is the layer d_1-d. Optical transmittance of such film is equivalent to transmittance of a birefringent lamina system, situated between two cross-oriented polarizers. Its transmittance will depend on the angle ♀ and the thickness d_1 as a periodic function, and the maximum transmittance can reach 50%. Existence of the transitional layer $d_1\text{-}d_2$ in this case does not change the physical situation in principal. Therefore, transmittance of polarized light by the herein declared optically anisotropic lamina will depend of what side the light is incident on it.

For the purpose of illustration of the herein declared invention, lets consider the following possible examples of its implementation, which do not exhaust all applications of the declared invention.

As it has been mentioned before, the film anisotropically absorbing light of at least one particular wavelength, is formed on a substrate, in capacity of which one can use a single-layer transparent lamina (glass, plastic, etc.) as well as a structure formed with at least two also transparent layers. The shape of the substrate can also be various. Its choice will be determined by the purpose of the end product.

It is necessary to give particular attention to the processing of the substrate surface, in order to create the desired parameters of the surface anisotropy. On the substrate, on at least that part of it where the optically anisotropic film with varying direction of optical axis throughout its thickness will be created, it is necessary to provide conditions for orienting molecules and/or supra-molecular complexes of LC material. Various methods could be employed for that purpose:

- The method of substrate surface activation, where resulting from chemical, ionic or any other processing of the substrate surface, an activation of chemical bonds of molecules is produced on the substrate surface, at which time the major alignment directions are created
- The method of creating a directional surface relief, where, using the material of the substrate itself or an additionally applied material, an oriented relief or textural elements or certain shapes and grooves, etc., is formed on the surface of the substrate. To achieve this, one can use the method of photo lithography to create smaller elements as well as the widely used for these purposes method of mechanical rubbing of the surface with a selected abrasive material (during mechanical processing it is advised to pay attention to the necessity of removing possibly created particles and cracks on the substrate surface, which could lead to distortions of the desired orientation).

Since this case makes use of the properties of liquid crystals to orient in the channel during flowing (application) along the axis of the channel, the necessary degree of orientation of supra-molecular complexes on the substrate surface will be determined by the depth and directionality of the substrate surface relief. In other words, a certain degree of surface anisotropy is created on the substrate.

Upon necessity, the relief could be created on one or more regions of the substrate, and different regions can have different surface properties. Also, there may be regions, which do not promote orientation of the liquid crystal.

Application of the liquid crystal film is implemented via known methods, similarly to the ones described in the patent US 5739296, which are based on rod, slot and roll methods. In these methods, the process of application of the liquid crystal solution layer is combined with the simultaneous orientation of already present supra-molecular complexes under the action of viscous forces, which appear in the process of application during stretching of the liquid layer or shearing of one layer relative to the other. For the purpose of creating spatially varying orientation of the polarization axis over the area of the polarizer, the application tool can change the direction of movement over the substrate surface. The speed of movement and the law of variation of movement direction will determine the orientation of the supra-molecular complexes of the liquid crystal.

In order to create the spatially varying orientation of the polarization axis during application of the polarizing film with the rotating cylindrical roll, grooves are formed on the surface of the roll at a predetermined angle, which induces the direction of orientation of the supra-molecular complexes, and consequently, the direction of the polarizing axis over the surface. The grooves can be created by reeling a thin wire (preferred diameter 20 – 150 μm) onto the roll under a certain angle to the axis of the roll, or by the methods of mechanical or chemical engraving. In the case of engraving, the profile of the grooves can be rectangular, rhomb-like, semicircular or other shape. The width of the grooves should preferably be in the range 50 – 500 μm, the depth 10 – 100 μm, the width of the wall over the top of the groove 10 – 50 μm.

Using roll with grooves with the given direction of the grooves allows forming polarizing drawings of various shape with various direction of polarization axis over the surface, and sequential use of several rolls with different dye colors allows creating multi-colored drawings. Moreover, the direction of the optical axis of the forming film on its surface will coincide with the direction induced by the grooves on the roll.

Combination of the above two effects on the liquid crystal (the alignment effect of the substrate and the external alignment influence of the application tool), depending on

which has greater contribution in the alignment of molecular complexes and with the condition of differing directions of action between the two, will determine the law of variation of the optical axis (axes) direction through thickness of the forming film.

Using various liquid crystal solutions of various concentration and viscosity one can obtain films of different thickness, which also will determine the degree of variation of the polarization axis through thickness of the film. With the rest of the manufacturing conditions the same, forming films of various thickness one could obtain films with greater or lesser twist of the polarization axis.

Experimentally, we have determined that in the result of such double-sided alignment action, not only the de-orientation of molecules on the volume of the film does not take place, but on the contrary, it becomes possible to obtain a polarizing film with a higher degree of orientation. The turn of the optical axis through thickness of the film happens without disturbance of order in the structure. As a result, the degree of polarization of the obtained film is no less, and in some cases higher than the known competitors, in which there is no variation of the polarization axis direction through thickness of the film.

In the capacity of the molecularly oriented organic materials, which form liquid crystals, one could use the known organic materials, which form thermotropic or lyotropic liquid-crystal phases, molecules of which form supra-molecular complexes (WO 94/28073).

The main condition for obtaining of optically anisotropic film with varying direction of the optical axis through thickness of the film is:

- Presence of anisotropic surface of the substrate, and the surface anisotropy of the substrate must be sufficient to provide resultant alignment effect on the supra-molecular complexes of the applicant LC;
- Presence of the external alignment action sufficient to provide resultant orientation of supra-molecular complexes of the applicant LC;
- Non-coincidence of directions of these two actions (here, the degree and the character of each alignment action will determine the law of variation of optical axis of the material throughout the thickness and over the surface of the film).

<u>Example of embodiment</u>

A layer of polyimide with the thickness of 50 – 100 μm is applied onto a glass plate via a known method.

It is rubbed with a cloth at an angle of 45° to the edge of the lamina. A water solution (8% wt. H_2O) of the liquid crystal of sulfonated indanthrone is applied on its surface by a known method (with the external alignment action on the liquid crystal). In solution, the molecules are grouped in stacks, comprising the supra-molecular complexes. During application of the LC solution the orientation of the complexes via taking place in the direction of the action.

The thickness before the operation of drying is 5 – 10 μm. The sample is dried in air at room temperature. Additional orientation of supra-molecular complexes takes place during drying.

After drying, the molecules in the near-surface layer are oriented so that their plane is directed perpendicularly to the direction of surface orientation, but in the upper layers – perpendicularly to the direction of film application.

Measurement of transmittance by the obtained sample is conducted with spectrophotometer in polarized light with wavelength of 640 nm. The plane of light polarization is oriented perpendicularly to the direction of film application. Measurement of transmittance is taken sequentially with two sample positions. At first the sample is oriented with the film toward the source of polarized light, then, the substrate toward the source. Depending on the thickness of the film, transmittance in the first case lays in the range from 0.5 to 5%, in the second – from 20 to 40%.

Polarizers obtained by the above-described method according to the invention, were characterized by the presence of anisotropically absorbing film with varying direction of polarization axis through thickness of the film. The method of obtaining of such film is simple the obtained film is continuous without breaks. It is possible to choose the optimum thickness of the film. The thickness of the polarizer is minimum. Moreover, polarizing effectiveness of the obtained polarizers is no less of the known competitors, which make use of analogous organic dyes. The given film may be used where it is necessary to achieve the mentioned quality, which constituted by the varying direction of the polarization axis through thickness of the film.

The possibility of obtaining optically anisotropic films with varying direction of the optical axis through thickness of the film, while simplifying the method of their manufacturing and providing reproducible optical parameters will substantially broaden the area of application of such films in science and technology.

Sources of information

RU 2110818, G02B, 1998.

US 5739296.

WO 94/28073.

CLAIMS

1. Optically anisotropic film of molecularly oriented organic material, wherein film has varying throughout its thickness direction of optical axis (axes) on at least a fraction of the film's thickness, for at least one region of the spectrum and on at least a part of the area of the film.
2. Optically anisotropic film according to claim 1, and distinct by the fact that the film is an anisotropically absorbing film, and/or phase-shifting film for at least one region of the spectrum.
3. Optically anisotropic film according to any of claims 1-2, wherein the first derivative of the function describing the variation of the angle of twist of the optical axis throughout the film's thickness is continuous.
4. Optically anisotropic film according to any of claims 1-3, wherein the function describing the variation of the angle of twist of the optical axis throughout the film's thickness is not symmetrical relative to the plane of any section of the film parallel to its surface.
5. Optically anisotropic film according to any of claims 1-4, wherein the film is obtained from liquid crystal of at least one organic matter, which forms lyotropic or thermotropic liquid-crystal phase, via application of the liquid crystal onto the substrate and utilizing the external alignment action, at least a part of the substrate surface possesses surface anisotropy, and the direction of the external alignment action does not coincide with the direction induced by at least a part of the substrate surface.
6. Optically anisotropic film according to any of claims 1-5, wherein the variation of the optical axis direction throughout the film's thickness is provided in the process of formation of the film via the effect on the LC of the anisotropic surface of the substrate and the external alignment action, while the directions of the mentioned alignment actions do not coincide.
7. Optically anisotropic film according to any of claims 1-6, wherein the law of variation of the polarization axis throughout the film's thickness is determined by the anisotropy of the substrate surface, and/or the direction and force of the external alignment action, and/or the thickness of the forming film, and/or the

viscosity of the employed liquid crystal, and/or the conditions of its application and drying.

8. Optically anisotropic film according to any of claims 1-7, wherein in the capacity of the organic matter for obtaining the liquid crystal was used at least one organic dye, which has in its structural formula at least one ionogenic group providing its solubility in polar solvents in order to obtain the lyotropic liquid crystal phase, and/or at least one non-ionogenic group providing its solubility in polar or non-polar solvents in order to obtain the lyotropic liquid-crystal phase, and/or at least one anti-ion, which in the process of formation of the optically anisotropic film either remain in the structure of the molecule or not.

9. Optically anisotropic film according to any of claims 1-8, wherein in the capacity of the organic dye, at least one organic dye of the form:

$$\{K\}(M)_n,$$

where, K – is the dye, chemical formula of which contains ionogenic group or several groups (same or different), which provide its solubility in polar solvents in order to form lyotropic liquid-crystal phase, M – anti-ion, and n- the number of anti-ions in a molecule of the dye, which could be a fraction in the case of sharing of one anti-ion by several molecules and in the case of n>1 anti-ions could be different.

10. Optically anisotropic film according to any of claims 1-9, wherein the film is formed by the multitude of supra-molecular complexes of one or several organic matters, and the supra-molecular complexes are oriented as to polarize passing light.

11. Optically anisotropic film according to any of claims 1-10, wherein the film consists of at least two fragments situated in one plane, axes of polarization of which on the surface of the film (in the near-surface layer) are directed at an angle relative to each other ranging from 0 to 90°.

12. Optically anisotropic film according to any of claims 1-11, wherein on its surface there has been formed and/or applied at least one optically anisotropic film, and/or at least one phase-shifting film, and/or at least one birefringent film, and/or

at least one alignment layer, and/or at least one protective film, and/or at least one film simultaneously serving as any combination of at least two of the above films.

13. Optically anisotropic film according to any of claims 1-12, wherein it is the polarizing film, and/or phase-shifting film, and/or birefringent film, and/or alignment layer, and/or protective film, and/or a film simultaneously serving as any combination of at least two of the above films on at least a fraction of the film's thickness, and/or in at least one region of the spectrum, and/or on at least a part of the film's area.
14. Optically anisotropic film according to any of claims 5-13, wherein the substrate is implemented with a polymer material or a glass, has flat, or convex, or concave or varying according to a certain law surface, and anisotropic qualities of the substrate surface on at least a part of its surface are provided by either the chemical bonds, relief or texture, created on the substrate surface either with the material of the substrate itself or with the applied onto the substrate surface material.
15. The method of obtaining the anisotropic film according to claim 1, wherein the formation of the film via application of the liquid crystal of at least one organic matter with removal of the solvent, distinct by the fact that in the process of film formation an external orienting action is imposed onto the liquid crystal and the film formed on the anisotropic surface of the substrate or alignment layer, while the direction of the external orienting action and the direction of the surface orientation of the substrate or layer are at an angle ranging from 0 to 90°.
16. The method of obtaining the anisotropic film according to claim 15, wherein the surface of the substrate and/or alignment layer consists of at least two regions with different direction of surface orientation.
17. The method of obtaining the anisotropic film according to any of claims 15-16, wherein in order to obtain surface anisotropy, a regular texture or a relief, is formed on the surface of the substrate with either the material of the substrate itself or the applied onto the substrate material via mechanical and/or chemical and/or ionic processing.

18. The method of obtaining the anisotropic film according to any of claims 15-17, wherein in order to provide additional variation of the direction of the polarization axis throughout the film's thickness, the direction of the orienting action over the surface of the film is changed during formation process.

19. The method of obtaining the anisotropic film according to any of claims 15-18, wherein regions with different properties are formed on the surface of the substrate, including ones with different direction of surface orientation.

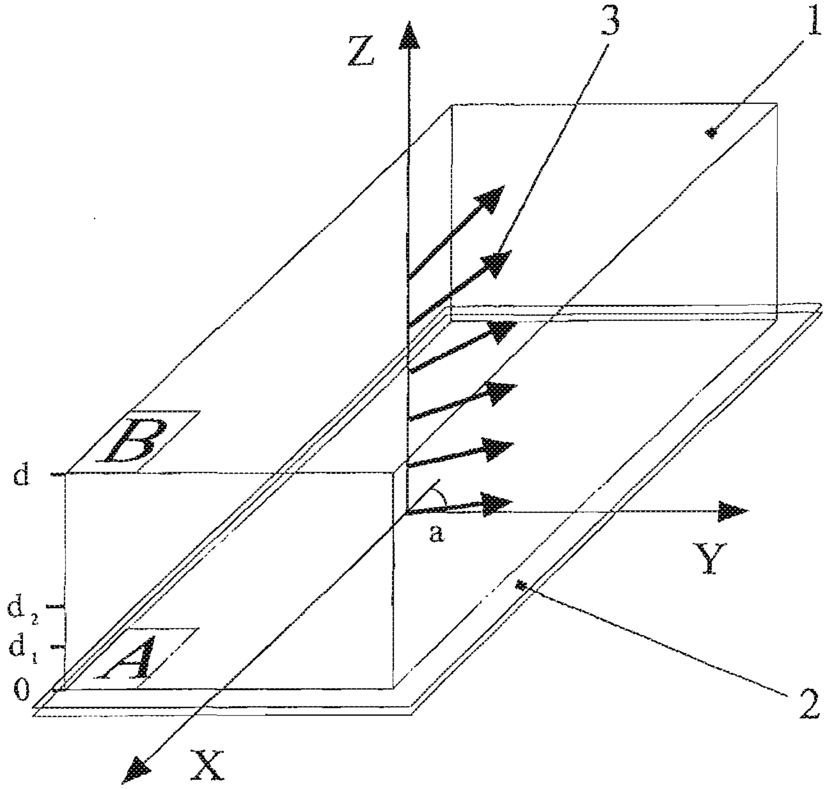

Fig. 1

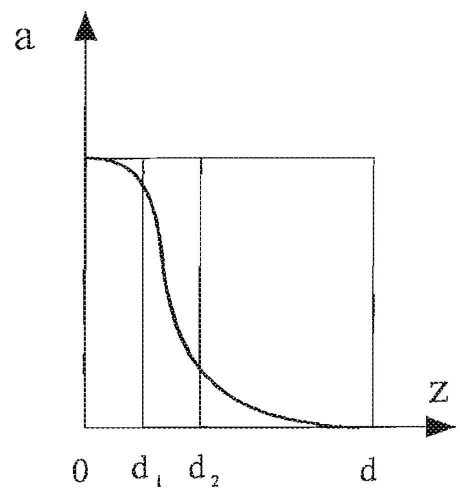

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/31073

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : G02B 5/30

US CL : 428/1.31, 359/97

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 428/1.31; 359/97

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
Please See Continuation Sheet

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,739,296 (GVON et al.) 14 April 1998 (14.04.1998), column 5, lines 45-68, column 6, lines 35-68, column 7, lines 1-68, column 10, lines 1-15.	1-19

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 14 January 2002 (14.01.2002)	Date of mailing of the international search report 24 JAN 2002
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Harold Pyon Jean Proctor Paralegal Specialist Telephone No. (703)305-0661

Continuation of B. FIELDS SEARCHED Item 3:
EAST 1.3
Search terms : anisotropic, dye, ionogenic, organic